FISHERIES AGENCY, MINISTRY OF AGRICULTURE AND FORESTRY
TOKAI REGIONAL FISHERIES RESEARCH LABORATORY
ICHITARO GENSHO, *DIRECTOR*

AUG 1954
LIBRARY
POFI
FISH & WILDLIFE
SERVICE

SPECIAL PUBLICATION No. 4

SPECIES OF FOOD PLANKTON FOR BALEEN WHALES IN THE SEA ADJACENT TO JAPAN

BY

ZINZIRO NAKAI

PRESERVATION OF FROZEN WHALE MEAT PRODUCED IN THE ANTARCTIC OCEAN

BY

KEISHI AMANO

RECENT DEVELOPMENT IN THE FRESHNESS TEST

BY

KEISHI AMANO

July, 1954

Tokyo

EDITORIAL NOTE

This series is intended to include those papers which have been submitted to international scientific meetings and are deemed to be adequate for further circulation. Reports in preliminary stages will also be published in this form from time to time for the purpose of throwing the high light upon some of important works requiring immediate dissemination.

TOKAI REGIONAL FISHERIES RESEARCH LABORATORY
Tsukishima, Chuo-ku, Tokyo

FISHERIES AGENCY, MINISTRY OF AGRICULTURE AND FORESTRY
TOKAI REGIONAL FISHERIES RESEARCH LABORATORY
ICHITARO GENSHO, *Director*

Special Publication No. 4

CONTENTS

Page

Species of Food Plankton for Baleen Whales in the Sea Adjacent to Japan . . . . . Zinziro Nakai 1

Preservation of Frozen Whale Meat Produced in the Antarctic Ocean . . . . . Keishi Amano 7

Recent Development in the Freshness Test . . . . Keishi Amano 9

Species of Food Plankton for Baleen Whales in the Sea Adjacent to Japan

ZINZIRO NAKAI†

I. Introduction

Numbers of reports have dealt with food plankton for baleen whales occurring in the North Atlantic and Antarctic Oceans. Above all, those which were worked out by N. A. Mackintosh and J. F. G. Wheeler[1], Johan Hjort and Johan T. Ruud[2], and J. T. Ruud[3], contain detailed accounts based on extensive researches into the subject. However, very few efforts have been paid even to the identification of the stomach contents of whales caught in waters adjacent to Japan.

The present paper is an attempt at introducing a brief review on species of food plankton for the whales caught in the coastal sea of Japan and in the northern North Pacific on the basis of previous works, though insufficient they might be, and on the identification conducted with samples made available more recently. In addition, a suggestion will be made about species of plankton which are assumed to be important for the mammals but have not yet been reported because of tardy progress in the stomach content surveys here in Japan.

The author wishes to acknowledge his obligations to Mr. Motohiro Sakurai, Chief of Kushiro Branch, Hokkaido Regional Fisheries Research Laboratory, and Mr. Takahisa Nemoto of the Whales Research Institute, Tokyo, who kindly offered rare samples of the stomach contents for his study. And Mr. Keijiro Maeda, Cheif of Whaling Branch, First Pelagic Fisheries Section, Fisheries Agency, was willing to lend the author a valuable reference in preparing the Japanese text which has been translated by Mr. Masao Ishida of the Laboratory. The anthor expresses his deep appreciations to both of them.

II. Summarized Review of the Food Plankton Surveys

1. Blue Whale: *Balaenoptera musculus* (LINNÉ)

During the months of June to August of 1941, Y. Matsuura and K. Maeda[4] conducted a whaling survey in the eastern coast of the Kamchatka Peninsula. In their report of the survey they wrote that blue whales in the area fed on *Euphausia pellucida* DANA. H. Omura,

† Chief Biologist, Marine Resources Section, Tokai Regional Fisheries Research Laboratory.

Y. Matsuura and K. Miyazaki[5] also referred to *E. pellucida* as a form of food for blue whales in the North Pacific. The specific name, *E. pellucida*, however, was canceled by H. J. Hansen[6] in 1905 when he classified it into four species as *E. mutica* H. J. HANSEN, *E. recurva* H. J. HANSEN, *E. diomedeae* ORTMANN, *E. brevis* H. J. HANSEN. According to Nakai and Honjo[11], *E. mutica* and *E. recurva* are distributed around the Bonin Islands. As H. J. Hansen and others have reported, the four species are occurring in warm sea regions; and very few of them has been found so far distributed in association with blue whales in coastal regions of Japan, the only species of *Euphausia* abundantly occurring in these waters being *E. pacifica*.

Several samples which had been obtained from blue, fin, and humpback whales caught in the sea south of the Aleutian Islands in the 1952 season were identified by Nakai and Honjo. On the basis of these identifications, H. Sakiura, K. Ozaki, and K. Fujino[7] have reported that Euphausiids which occurred in the stomachs of the three species of whales belong to one of either species of *Thysanoessa longipes*, *T. inermis*, or *T.* sp., or the mixture of them. According to a further study on the same samples made by Nakai and Honjo[8], the first two, *i.e.*, *T. longipes* and *T. inermis* were food of the blue whales. Identification of some more samples brought back from the same region in the 1953 season was also pursued by Nakai and Honjo[9]. Important species were this time *T. inermis* and *Euphausia pacifica* except for a few amounts of *T. longipes* and *Themisto* sp.

Plankton recovered from blue whales in the region under review are listed here with asterisks on those which are likely important species.

Euphausia pacifica H. J. HANSEN*
Thysanoessa longipes BRANDT*
T. inermis KRÖYER*
T. sp.
Themisto sp.

2. Fin Whale: *Balaenoptera physalus* (LINNÉ)

Based on the samples obtained from fin whales caught off the southeastern coast of Korea on the Sea of Japan during the years of 1939 to 1942, Nakai[10], and Nakai and Honjo[11], briefly mentioned that all the food found in the stomachs of the fin whales were *Euphausia pacifica*. In the whaling survey of 1941 referred in the preceding paragraph, Y. Matsuura and K. Maeda[4] reported that most of fin whales in that part of the North Pacific were found living greatly on *E. pellucida*, the species which had been canceled by H. J. Hansen

as stated above. Sometimes fin whales fed on *Calanus cristatus*, according to their report.

H. Sakiura, K. Ozaki and K. Fujino[7] informed that fin whales captured in the south of the Aleutian Islands in 1952 contained in their stomachs *Calanus cristatus* and Euphausiids, in accordance with the identification performed by Nakai and Honjo. Species of Euphausiacea from these samples were proved by the two planktologists[8] to be *Thysanoessa inermis* and *T.* sp. The planktologists[9] found the samples which were forwarded from the same whaling ground in 1953 to consist primarily of *Calanus cristatus*, *Thysanoessa longipes* and *T. inermis* along with the mixture of a few species such as *Calanus plumchrus*, *Euphausia pacifica*, *E.* sp., *Themisto* sp., and *Sagitta elegans*. On October 16, 1953, a fin whale was seized off the eastern coast of Hokkaido at the point of lat. 41°09′ N. and long. 146°54′ E. The stomach content of the whale showed no other species but *Euphausia pacifica*.

Of the above species, *Thysanoessa inermis*, often called as "small krill", is regarded by J. Hjort and J. T. Ruud[2], and J. T. Ruud[3] as food for fin whales in the north European part of the Atlantic. It is interesting to note that this species of Euphausiacea is a common and important one both in the Pacific and the Atlantic.

The plankton recovered from fin whales are listed as follows:

Calanus cristatus KRÖYER*
C. plumchrus MARUKAWA
Euphausia pacifica H. J. HANSEN*
E. sp.
Thysanoessa longipes BRANDT*
T. inermis KRÖYER*
T. sp.
Themisto sp.
Sagitta elegans VERRILL

3. Sei Whale: *Balaenoptera borealis* LESSON

In the 1941 North Pacific whaling survey mentioned above, the same authors[4] indicated that sei whales caught there mostly fed on either *Metridia lucens* BOECK or *M. longa* (LUBBOCK). S. Nishimoto, M. Tozawa and T. Kawakami[12] described the stomach contents of sei whales caught around the Bonin Islands in 1951 to be *Thysanoessa gregaria*, upon the identification made by S. Motoda. Some more samples provided from the same region in the same year were determined by Nakai and Honjo[11]. The samples almost exclusively were *Euphausia similis*.

Samples of the stomach contents have scarcely been made available even from the sea off Sanriku and Hokkaido regions, one of the most expansive grounds for sei whales in Japan. However, a sei whale, 39 feet in body length, was harpooned at the sea of lat. 42°57′ N. and long. 146°53′ E. on September 21, 1953, and one more at lat. 40°23′ N. and long. 144°28′ E. in the south of Erimo Saki, Hokkaido, just on 2nd of this month, July 1954. Nearly all the plankton come out of both whales were *Euphausia pacifica*.

In connection with species of the said whales, it has to be pointed out here that most of the sei whales in the Bonin area, though have been hitherto regarded as such, likely belong to bryde's whales, *B. brydei* OLSEN, while those occurring off Sanriku and Hokkaido are considered primarily as the true sei whale (H. Omura, S. Nishimoto, and K. Fujino[13]; H. Omura and K. Fujino[14]). And when the identification was carried out with samples from the Bonin area, it was impossible for the planktologists to ascertain as to which one of the closely associated species provided the samples.

Plankton found from sei whales caught in these waters are listed as follows:

Metridia lucens BOECK
M. longa (LUBBOCK)
Euphausia similis G. O. SARS*
E. pacifica H. J. HANSEN*
Thysanoessa gregaria G. O. SARS

4. Humpback Whale: *Megaptera nodosa* (BONNATERRE)

As has been stated in the foregoing paragraph, humpbacks were one of three species of baleen whales caught in the Aleutian area in 1952. The food recovered from the other two, blue and fin whales, were either one of *T. longipes*, *T. inermis* or *T.* sp., or their mixture. A detailed study by Nakai and Honjo[8] about the stomach contents of those humpback whales revealed that they consisted of *T. inermis* and *T.* sp., with occasional mixture of *Calanus cristatus*. The two planktologists[9] were engaged in the identification of the 1953's sample from the same region. This time a substantial part was *T. longipes* with a few mixtures of *Calanus cristatus* and *Thysanoessa* sp. No information has been available about food of humpbacks in the coastal regions of Japan.

Plankton occurred in the stomach of the whale are:

Calanus cristatus KRÖYER*
Thysanoessa longipes BRANDT*
T. inermis KRÖYER*
T. sp.

5. Least Rorquel: *Balaenoptera rostrata* (GRAY)

As far as the mammals in the neighboring waters to Japan are concerned, no report except one prepared by Nakai and Honjo[11] seems to have dealt with the food for this species of whales. In their report, they stated that the samples of least rorquels caught along the southern coast of Korea on the Sea of Japan presented *Euphausia pacifica* H. J. HANSEN in their stomachs.

6. Right Whale: *Balaena glacialis* BONN

The only available source of information of plankton fed by this species of whales is the 1941 North Pacific whaling survey in which Matsuura and Maeda[4] wrote that a right whale was found with a few amounts of *Calanus plumchrus* MARUKAWA in its stomach.

7. Unidentified Species of the Food

In addition to established species of food plankton as referred above, a few remarks should be given to those plankton reported by several authors who did not identify their samples with specific names. Among them K. Mizue[15] dealt with stomach contents of tremendous numbers of whales. His records were collected from 4,982 heads of various whales captured during the period of 1946 to 1948 at many localities such as Okhotsk and Pacific coasts of Hokkaido, waters off Sanriku, and Wakayama Prefecture, and the Goto Islands. On the basis of the results determined at land stations in those regions, he informed of *Euphausia* sp. and *Calanus* sp. to be food for blue, fin, sei, and humpback whales. The exact specific names of the plankton were not secured, however.

III. Important Species Remained to be Reported

Apart from the reported species of food for whales mentioned above, there should be, at least, two species of plankton which seem to have important bearing upon whales in the light of specific and quantitative distribution and ecological knowledge of macroplankton in coastal waters of Japan. One is *Calanus finmarchicus* GUNNERUS which occurs almost throughout the littoral waters of this country, the other, *Pseudeuphausia latifrons* G. O. SARS in the East China and Yellow Seas. According to J. Hjort, J. T. Ruud[2] and J. T. Ruud[3], the former is also a valuable form of food for sei whales in the Norwegian waters, as is known by the local name of "red food". Since it is one of copepods extensively distributed in littoral waters of Japan, *C. finmarchicus* is very likely an important food for sei whales living in this part of the oceans as well. Distributed in great quantities in the East China and

Yellow Seas, the latter, *Pseudeuphausia latifrons*, play a significant role as food for the horse mackerel, *Trachurus japonicus*, and the mackerel, *Pneumatophorus japonicus japonicus*, in the sea south of Korea. In view of the fact, the plankton are supposed to be important food also for baleen whales, though further investigations should be undertaken before confirming relationship between these species of plankton and whales.

Literature Cited

(1) N. A. Mackintosh and J. F. G. Wheeler. 1929. Southern Blue and Fin Whales. Discovery Rep., Vol. I.

(2) Johan Hjort and Johan T. Ruud. 1929. Whaling and Fishing in the North Atlantic. Rapp. et Proc. Verb., LVI.

(3) Johan T. Ruud. 1932. On the Biology of Southern Euphausiidae. Hvalrådets Skrifter, Nr. 2.

(4) Y. Matsuura and K. Maeda. 1942. Biological Survey of Whales in the North Pacific. (In Japanese) Nippon Whaling Industrial Association.

(5) H. Omura, Y. Matsuura and K. Miyazaki. 1942. Whales—Their Science and Whaling Operation. (In Japanese) Suisan-sha, Tokyo.

(6) H. J. Hansen. 1905. Preliminary Report on the Schizopoda Collected by H. S. H. Prince Albert of Monanco during the Cruise of the Princess Alice in the Year 1904. Bull. du Mus. Oceanogr. de Monaco, No. 30.

(7) H. Sakiura, K. Ozaki and K. Fujino. 1953. Biological Investigation of the Northern Pacific Baleen Whales Caught by the Japanese Whaling Fleet in 1952. Fish. Agen., Jap. Gov.

(8) Z. Nakai and K. Honjo. (Unpublished) Food of Baleen Whales in the Northern North Pacific.

(9) ———— 1954. Stomach Content of Whales Caught by the "Baikal Maru" Fleet in the North Pacific, May-September 1953 (Preliminary Report). (In Japanese) Committee for the Improvement of Equipment of Whaling Vessels.

(10) Z. Nakai. 1942. The Chemical Composition, Volume, Weight and Size of the Important Marine Plankton. (In Japanese with English abstract) Jour. Oceanogr. Soc. Jap., Vol. I, Nos. 1–2.

(11) Z. Nakai and K. Honjo. 1953. Plankton and their Relation to Distribution of Whales in Hokkaido, Sanriku and Bonin Regions, 1950–1952. (In Japanese) Committee for the Improvement of Equipment of Whaling Vessels.

(12) S. Nishimoto, M. Tozawa and T. Kawakami. 1952. Food of Sei Whales Caught in the Bonin Island Waters. Scien. Rep. of Whal. Res. Inst., No. 7.

(13) H. Omura, S. Nishimoto and K. Fujino. 1952. Sei Whale (*Balaenoptera borealis*) in the Adjacent Waters of Japan. Japan Whaling Association.

(14) H. Omura and K. Fujino. 1954. Sei Whales in the Adjacent Waters of Japan, II. Further Studies on the External Characters. Scien. Rep. of Whal. Res. Inst., No. 9.

(15) K. Mizue. 1951. Food of Whales (In the Adjacent Waters of Japan) Scien. Rep. of Whal. Res. Inst., No. 5.

Preservation of Frozen Whale Meat Produced in the Antarctic Ocean

Keishi Amano*

It is interesting to notice that the whaling industry of the world has become increasingly aware of importance of whale meat as a potential source of animal protein for undernourished population. However, there are many technical difficulties to be sloved before quantities of whale meat now almost wasted in the sea can be fully utilized and appreciated by greater numbers of the nations. In Japan biochemical changes in whale meat during the course of various treatments from killing to defrosting have been studied particularly with whale caught by Japanese whaling fleets in the Antarctic Ocean since 1948, two years after the area was reopened to them. In these studies an emphasis has been placed on finding a means which enables us to preserve freshness of frozen whale meat in a more suitable state for the nation's food. The following is a summary of the results obtained so far from our research.

A) The time in which carcasses of whale were left floating or otherwise before freezing did not affect quality of the meat under the conditions of temperatures of atmosphere and water in the Antarctic region. It proved that no perceptible change was introduced in the general area of the meat of the catch left floating in the cold sea water for about 12 hours before processing unless they were exceedingly exhausted at the moment of killing.

B) Sometimes carcasses had to be towed through a rough sea for nearly six hours to reach a mothership. Even after such a difficulty no symptomatic deterioration of the meat was observed with the exception of the meat adjacent to the harpoon wound which was affected in such a way as the nearer to the wound, the more pronounced was the deterioration.

C) The deterioration is supposed to progress after, rather than before, dissection of the carcasses when the meat is left exposed on board for hours prior to freezing. The phenomenon, though hardly avoidable, can be detected by the increasing amount of ammonia in the surface tissue of the meat even from a fresher carcass, and still more with one which has already been debased to some extent in the

* Biochemist, Marine Product Utilization Section, Tokai Regional Fisheries Research Laboratory.

result of exhaustion at the time of catching. Showering the dissected body in sea water was found helpful to check progress of the deterioration in some degree and wash away putrefied products such as ammonia.

D) The sample which was processed soon after catching with the muscle remaining in the pre-rigor state likely results in the thaw-rigor when defrosted, exuding amounts of drip. The phenomenon, one of factors related to contraction of the muscle tissue, is dependent on the amount of adenosine triphosphate (ATP) which has been kept present in whale meat during cold storage. However, the thaw-rigor can be prevented either by pre-cooling of whale meat for several hours before freezing, or by storing the frozen meat for a period from two weeks to a month before marketing, at temperatures of $-5°$ to $-10°$C, respectively. Because the amount of ATP would be reduced by these treatments. The latter method, however, may not be recommendable for commercial purpose as a greater part of the meat tends to turn to dark color during the storage.

A remarkable biochemical reaction in the thaw-rigor is a rapid reduction of sulfhydryl group which takes place much in parallel with decrease of ATP. The reason is probably ascribed to change in SH group which promotes combination of myosin with actin.

E) The amount of drip does not seem to depend on the sea-water washing applied to the meat before freezing, nor on different processing methods such as air freezing as compared with sharp refrigeration using a flat tank. Neither internal pressure of the muscle tissue increased by freezing appears to influence the drip, although it has not been confirmed.

F) A merit of the sharp freezing in a flat tank is that it hardly permits time for whale meat to change the quality before starting to freeze. When subjected to air freezing, on the other hand, the surface tissue is unaviodably deteriorated to some extent.

G) Colors on the surface of whale meat which has been affected by pre-cocling in sea water and blooding operation are capable of restoring by degrees just as freezing proceeds, as far as the appearance is concerned. However, color pigments washed out of the meat by showering cannot be recovered; and the meat thus treated looks discouragingly inferior to those which were not treated by sea water.

H) Not very tastful is the whale meat which is so fresh as to show thaw-rigor. But the meat in this state, regardless whether it is cooked or not, never gives out a disagreeable smell.

Recent Development in the Freshness Test*

KEISHI AMANO**

Studies on methods determining freshness of fish meat and fish products have been drawing attentions as one of significant research projects in Japan after World War II. Because technical progress in this field of biochemistry has been greatly stimulated by an urgent necessity of inspectors who examine the quality of fish for public health, and of frozen or canned products for export. For these purposes, it is not sufficient to propose a method which is useful for laboratory technique alone. Not only accuracy of the result but simplicity and readiness of handling are also essential for the inspectors as they have to examine numbers of samples in a limited time at fish markets or cold storehouses.

Taking these requisitions into consideration, Amano (1948, 1949 and 1950)[1-5] suggested that precipitation test of the aqueous extract from fish meat with mercuric chloride is suitable for simple and quick determination of the freshness, a method which was originally introduced by W. Walkiewicz (1936)[6] for the test of raw beef and other commercial meats. Amano has found that in the first stage of decomposition, mercuric chloride reacts chiefly with protein in water extract of the muscle, and that as deterioration advances, lower molecular nitrogenous compounds appear to play a role in the precipitation. The method is now extensively put into practice by public health inspectors of local health centers in this country.

Sulfhydryl group in the aqueous extract of fish meat was proposed as a reliable index of the freshness by Mori and Hata (1949)[7] when they succeeded in simplifing Mirsky and Anson's ferricyanide method[8] for a rapid estimation of SH group in the fish muscle. In their experiment the amount of volatile basic nitrogen was well correlated with that of sulfhydryl group.

Recommending para-quinone method as a quick freshness test, Obata and his co-workers (1950)[9-11] reported that in the course of decomposition of fish, piperidine or pyrrolidine is formed as the end product of certain amino acids such as arginine. These substances, they suggested, are probably responsible for foul odor of decayed fish meat. In this method reddish brown color of piperidyl quinone or pyrrolidyl quinone

* Contribution to the 8th Pan Pacific Sciences Congress, Manila, November 1953.

** Biochemist, Marine Product Utilization Section, Tokai Regional Fisheries Research Laboratory.

must be instantly compared with a standard color solution prepared by mixing potassium bichromate and cobalt nitrate. The test proved applicable to the examination of canned fishes and vitamin oils as well.

Tomiyama and others (1951)[12] found that a catalase activity test is convenient for the purpose. For catalase activity in the gill tissue, perhaps of bacterial origin, was ascertained to increase with progress of spoilage. In addition to permanganate method, a simple manometric apparatus for the practical purpose was deviced by them. This type of the test, according to them, has an advantage in using the gill for the examination, while saving edible parts of fish to be sold, if permissible, at market.

In view of a fact that volatile basic nitrogen is generally supported as a freshness indicator of fish meat, efforts have been paid to curtail the time required for determining ammoniacal nitrogen. Ohta (1950)[13-14] has presented a rapid colorimetric estimation of ammonia in the fish muscle by applying Nessler's technique to his experiment, paying special precaution to remove interfering substances from deproteinized extract of the sample.

It was Kawabata (1953)[15] who also examined certain factors affecting the velocity constant in removing volatile nitrogen by aeration to observe typical difference in the velocity constant among volatile amines such as methylamines and ethylamines. Susceptibility of volatilization for each of these amines is stood in the following order: tertiary methylamine, NH_4Cl, primary, and secondary methylamine: tertiary, secondary ethylamine, NH_4Cl, and primary ethylamine. No difference of the velocity constant was noted between organic and inorganic ammonium compounds. He remarked that the amount of liquid added to the aeration tube had a considerable effect to decrease recovery of nitrogen from the sample.

In an attempt at improving the vacuum distillation of volatile nitrogen, Tomiyama (1952)[16-18] successfully employed a higher temperature in the distillation so as to minimize the time necessary for the determination.

Since the work of Beatty and Gibbons (1937)[19] had been made public, trimethylamine test was frequently studied by Canadian workers and considered as an exact index of freshness of fish meat. Fujimaki[20] discovered that the trimethylamine content of steamed albacore meat is always higher than that of raw meat of the fish when tested by both Dyer's picric acid method[21] and Cromwell's cis-aconitic acid method.[22] Something capable of reducing trimethylamine oxide is likely to be formed in the fish muscle during the cooking process. As a result, the value of the amine becomes higher than before steaming because

of accumulation of the newly formed amine onto the original amount, he explained. What sort of compound plays the role in this reduction has not yet been known, though sulfhydryl group is supposed to be a probable reductant in the heat-treated fish muscle. In this connection it should be remembered that the trimethylamine test is not feasible for the quality examination of canned fish.

In order to find out the most adequate part of the body to be sampled for the freshness test, pH measurement was carried out by Kawabata and his collaborators (1952)[23] on albacore meat. Marked differences were observed in pH values of the muslces of the fish tested soon after catch, depending on anatomical localities examined. The values of pH of the muscles in the head and around the pectoral fin were found unsuitable for the quality index of fish since they were not always parallel with freshness of the trunk muscle. The variation observed in pH of fresh muscle was related to the amount of lactic acid. A reason for the occurrence of higher pH values in the orbital muscle and buccinator was explained by a low content of this acid.

Tomiyasu and his cooperators (1952)[24] described a method based on $KMnO_4$ consumption of the steam distillate of fish muscle in which reference was made to a study of Farber.[25] They informed that an increasing curve of $KMnO_4$ consumption was sharper than that of volatile basic nitrogen simultaneously measured as an index of spoilage.

An experiment conducted by Suzuki (1953)[26] revealed that the aqueous extract of fish muscle inhibits Krüger's lanthan blue reaction for acetic acid, and that the inhibitive extent becomes greater with development of spoilage. The amount of extract necessary to impede this reaction was proposed as a measurement to be used by investigators in determining the freshness.

Upon a series of experiments on the voltatile acid contents of various kinds of fish, Asakawa (1953)[27-28] gave an account that the volatile acids with more than four carbon atoms in their chains grow in quantities when decomposition progresses. Making use of ready volatility of higher volatile acids, he proposed ratio of the acids' amount in a first 50 cc. distillate to that in 50 cc. of the second. If the material fish is not fresh, this quotient will be much lower than that obtained from a really fresh muscle.

Among physical methods for evaluating the freshness, electrical resistance of fish muscle was frequently examined.[29-31] However, little evidences were recorded to warrant practical application of the method. Perhaps complicated conditions involved in sampling fish muscle may give rise to difficulties in securing reproducible measurements. Hotani (1951)[32] confirmed by damping oscillation method that the internal

friction of fish meat varies depending on the freshness, a knowledge on the basis of which an apparatus to indicate the internal friction of muscle piece was designed. It is interesting to note that this indicator, if improved, will be of use in determining freshness of frozen fish without defrosting.

Despite considerable amounts of effort devoted to the problem, most of the tests reviewed here are still in a stage insufficient to be credited with public approval ; and it is very difficult to recommed a method available for the over-all purposes. Because there are too many species of fish and too much varieties in fish products as well as in decomposition of fish meat to determine the freshness with a single standard. For this reason we cannot help selecting, for the time being, some methods which are comparatively faultless in practice.

Summary

Researches on the freshness test of fish meat were stimulated in Japan with an urgent need for a simple and rapid method to be provided for both inspection of daily fisheries products for public health and quality certifications of the marine food for export. An outline of the studies which have been carried out since the end of World War II is presented. Among numbers of examinations attempted at this purpose, two or three methods may be applicable for practical service. These considered suitable for field works are pH test, reaction of protein precipitation with mercuric chloride, and rapid ammonia test.

References

1. K. AMANO and H. UCHIYAMA: Bull. Jap. Soc. Sci. Fish., 14, 48–50 (1948).
2. ———: Ibid., 14, 165–172 (1949).
3. K. AMANO, H. UCHIYAMA and F. TOMIYA: Ibid., 15, 262–266 (1949).
4. K. AMANO and F. TOMIYA: Ibid., 15, 753–758 (1950).
5. K. AMANO: Bull. Tokai Regional Fish. Lab., 1 (Contr. A) pp. 136 (1950).
6. W. WALKIEWICZ: Z. Fleisch- u. Milchhyg., 46, 171–174 (1936).
7. T. MORI and M. HATA: Bull. Jap. Soc. Sci. Fish., 15, 407–411 (1949).
8. A. E. MIRSKY and M. L. ANSON: J. Gen. Physiol., 18, 307 (1935).
9. Y. OBATA and H. ZAMA: Bull. Jap. Soc. Sci. Fish., 15, 499–504 (1950).
10. ———: Ibid., 16, 10–14 (1950).
11. Y. OBATA and M. ISHIDA: Ibid., 16, 147–150 (1950).
12. T. TOMIYAMA, Y. YONE and K. IDE: Ibid., 16, Special Number 17–24 (1951).
13. F. OHTA: Ibid., 16, 44–50 (1950).
14. ———: Ibid., 17, 309–312 (1952).
15. T. KAWABATA: Ibid., 18, 525–529 (1953).
16. T. TOMIYAMA, K. IDE and T. AKIYAMA: Ibid., 17, 13–18 (1952).
17. T. TOMIYAMA: Ibid., 17, 37–41 (1952).
18. T. TOMIYAMA and Y. HARADA: Ibid., 18, 20–24 (1952).

19. S. A. Beatty and N. E. Gibbons: J. Biol. Bd. Can. 3, 77 (1937).
20. M. Fujimaki: J. Soc. Agr. Chem. (In press).
21. W. J. Dyer: Fish. Res. Bd. Can. Prog. Rep. Atl., 34, 4 (1943).
22. B. P. Cromwell: Biochem. J., 46, 578–581 (1950).
23. T. Kawabata, M. Fujimaki, K. Amano and F. Tomiya: Bull. Jap. Soc. Fish., 18, 124–132 (1952).
24. Y. Tomiyasu, M. Toyomizu and K. Takahashi: Sci. Bull. Fac. Agr., Kyushu Univ., 12, 391–398 (1952).
25. L. Farber: Food Tech. 6, 319–324 (1952).
26. T. Suzuki: Bull. Jap. Soc. Sci. Fish., 19, 106–110 (1953).
27. S. Asakawa: Ibid., 19, 118–123 (1953).
28. ———— : Ibid., 19, 124–131 (1953).
29. K. Yamada and E. Kitano: Ibid., 13, 232–236 (1948).
30. H. Ito, T. Kyozuka and C. Sugizaki: J. Soc. Agr. Chem., 23, 192–193 (1949).
31. T. Matsui: Personal communication.
32. S. Hotani: J. Tokyo Univ. Fish., 38, 59–61 (1951)

List of Special Publications

of the

Tokai Regional Fisheries Research Laboratory

No. 1: On Fishery for "Iwashi" (Sardine, Anchovy and Round Herring) and Research of its Resources in the Japanese Waters, by Zinziro Nakai.

Issued October 1952.

No. 2: On Quantitative Distribution of Plankton Reproduced in the Northern Pacific, by Zinziro Nakai.

Issued October 1952.

No. 3: A Report on Oceanographical Investigations in the Salmon Fishing Grounds of the North Pacific, 1952 and 1953, by Nobuo Watanabe.

A Preliminary Report on Surveys of Plankton and Salmon Stomach Contents from the North Pacific, 1952, by Zinziro Nakai and Koji Honjo.

Issued January 1954.

No. 4: Species of Food Plankton for Baleen Whales in the Sea Adjacent to Japan, by Zinziro Nakai.

Preservation of Frozen Whale Meat Produced in the Antarctic Ocean, by Keishi Amano.

Recent Development in the Freshness Test, by Keishi Amano.

Issued July 1954.

Printed by
Kokusai Bunken Insatsusha
Chiyoda-ku, Tokyo.